XYZ Axis PLC

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***Abstract*— Programmable Logic Controllers, or PLCs, are devices used to control anything from simple LEDs to complex industrial systems through an easy-to-use logic program. The purpose of our project was to create a 3-axis motion controlled mechanism commanded by PLCs that can be used to move objects from one point to another. This was done with 2 stepper motors connected to lead screws that in turn moved slides, along with an electric piston actuator with an electromagnet connected to the end. The two stepper motors were used to move the piston along an X- and Z-axis to position it above an object. The actuator was then activated to lower the electromagnet in the Y-axis direction, to the object, energize the magnet, collect the object, and raise. The slide system then moves the piston and object to another point, lowers the object, releases it, and retracts to the starting position. This mechanism can be used for demonstration purposes to educate high school students about the uses of PLCs and how they are programmed. It will also be used in the Automation class to implement motion control applications.**

I. Introduction

The purpose of this project was to create a demonstration model to show the intricacies of Programmable Logic Controllers (PLCs) and some of the uses they might have. This model was aimed toward an audience of high school students, so its main purpose was to simply show them how a PLC works. While there are other PLC demonstration models on the market, those models only contain simple switches and LEDs, limiting the usage of a PLC. Our design includes moving parts to help not only captivate the audience, but also show more of the complex uses of the PLC while keeping it a simple demonstration. In addition, this model will be used for instruction in motion control applications.

To make our demonstration model (demo), we decided we wanted to replicate a simple crane machine, like the ones filled with toys at supermarkets. Using those machines as a reference, we realized we needed something to grab objects and to be able to move that grabber along three different axes. We concluded that the best way to move in three linear directions was to use three linear actuators. Two of the actuators are stepper motor driven actuators (slides) and the third is a piston-like electrical actuator (piston). The two slides were set up to move along two of the three axes, X and Z, covering movement to the left, right, forward, and backward. That left the remaining piston to move up and down along the Y-axis. Lastly, for our grabber, we chose a simple electromagnet that was attached to the end of the piston. This meant we need a ferromagnetic material for our objects, such as iron, steel, or other magnetic metals. After some discussion, our best option was small steel blanks available through the university machine shops.

Once we combined all three of the actuators into one mechanism, our next step was to create a program that would move the actuators to a desired position. Since we were working with a Productivity 2000 Series PLC, we used the accompanying software, Productivity Suite, and the ladder logic. We wanted the actuators to move on command, so we controlled them with push buttons and some physical limit switches. For safety reasons, we also planned to incorporate a safety switch to shut the entire system down, along with translucent safety covers for the demonstrations. Since the stepper motors need pulses to move, [1] we also used step drivers provided by the university to help control movement of the motors.

II. Technical Methodology

The first part of our project was the program. The main objective of this program is to send electrical signals to the stepper motors and piston to make them move on command. The original program we were given at the start of the project did not communicate the move commands properly. We then tested the command with a sample program from Automation Direct, along with some new programs we wrote from scratch. Eventually, we decided to start from scratch instead of keeping the original program. Once we did, we were able to learn the proper programming to set up the move commands and both of the motors moved on command. With this breakthrough, we moved on to wiring the mechanism.

We started by connecting both step drivers to the link for the PLC based on the wiring schematic (Fig. 1) for the first driver and copying it for the second. After the step drivers were wired into the stepper motors, we wired the control push buttons, the start switch, and the safety switch. To prevent confusing the buttons and switches, each pair of buttons (corresponding to each axis of motion) were wired with different colors, along with different colors for the switches. We also labeled all of the wires to make sure we could consistently reassemble the system without trouble.

Our next step was to design and build a frame for the mechanism to rest and operate on. The design (Fig. 2) was simple so assembly and disassembly could be streamlined, and storage would be less problematic. Once the frame was assembled, we mounted the mechanism and wired the entire system for testing. Once we finished multiple rounds of testing, we were able to move forward with the next step of the project: designing the safety features.

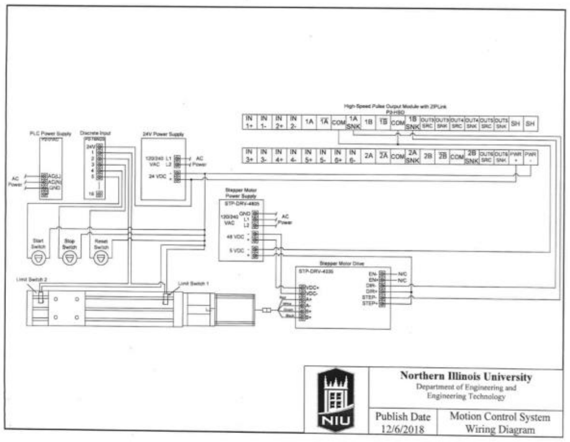

Fig.1- Wiring schematic

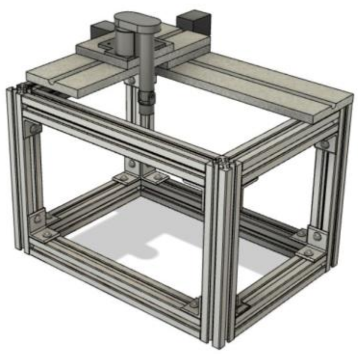

Fig. 2- Frame and Mechanism Model

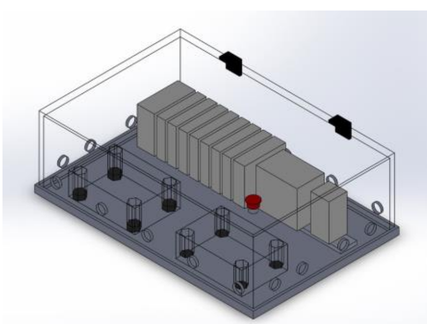

Fig. 3- Safety container for electrical components

With the project nearing its finished state, all that was left was to design, create and implement the necessary safety features so no one could get hurt during a demonstration. These safety features (Fig. 3-4) were planned to be made from sheets of clear acrylic so the project and all of the components, both electrical and mechanical, would be visible for the audience. We wanted to make sure everyone could have a good time while also staying safe.

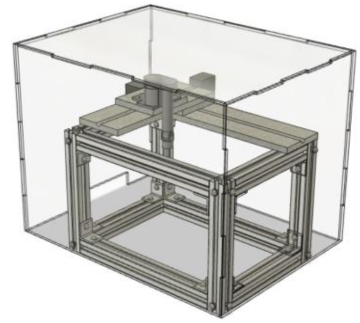

Fig. 4- Safety Container for Mechanical Components

III. Conclusion and Recommendation

The main objective of our project was to design a 3-axis motion controlled pick and place system. This was done by taking three linear actuators, two slides and one piston, and orienting them so they could move freely as one coherent mechanism. This mechanism is controlled by a PLC program, which is set to drive the mechanism on command. The mechanism is then mounted to the top of a frame constructed of t-slotted railing. From there, the mechanism can act as a crane machine by moving into position on command over an object, picking the object up, and moving it to a new location.

One of our highest goals of this project was to make our demonstration model reproducible. Our project is being made with very expensive parts because they were available to us at no cost, but we would not suggest using the exact same parts in every model due to cost constraints. Instead locate parts that have the same or similar functionality at a much lower cost to help save money on the overall cost of this project. Lastly, we recommend staying in contact with the producers of any acquired parts, as they can be very helpful resources during troubleshooting.

Acknowledgment

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References

[1] Hassan, S., Yusof, M. S., Embong, Z., Kamarudin, Q. E., Haq, R. H. A., Ibrahim, M., et al. (2018, Jul 16-17). A study of frequency and pulses for stepper motor controller system by using programmable logic controller. Paper presented at the 8th International Conference on Mechanical and Manufacturing Engineering (ICME), Johor Bharu, MALAYSIA.